DESIGN OF A SINGLE PHASE RELUCTANCE START INDUCTION MOTOR

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DEDICATION

This project is dedicated to the almighty Allah, the Lord of the World, the most beneficent and the most merciful and the sustainer of my life to Him all thanks and praise belongs. This project is as well dedicated to my beloved parents MALLAM ABUBAKAR IKAGWU and REKIYA ABUBAKAR.

DECLARATION

I, ...ABUBAKAR YAQUB.................... declares that this work was done by me and has never been presented else where for the award of a degree. I also hereby relinquish the copyright to the Federal University of Technology, Minna.

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ABSTRACT

A single phase reluctance motor is constructed so that either the rotor or the stator (or both) has poles in which there are areas of different saturation induction (thereby forming an asymmetric saturation characteristic in these poles), as a result of which an aligned position of the movable member becomes non - aligned at increasing excitation current and the movable member begins to move in a predetermined direction.

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CHAPTER ONE

1.0 INTRODUCTION

The principle of conversion of electrical energy into meohanical energy by electromagnetic means was demonstrated by the British Scientist Michael Faraday in 1821 and consisted of a free hanging wire dipping into a pool of mercury. A permanent magnet was place in the middle of the pool mercury. When a current was passed through the wire, the wire rotated around the magnet, showing that the current gave rise to a circular magnetic field around the wire.

This motor is often demonstrated in school physics classes, but Brime (salt water) is sometimes used in place of the toxic mercury. This is the simplest form of a class of electric motors called homopolar motors. A later refinement is the Barlow's wheel. These were demonstration devices, unsuited to practical application due to limited power [4]

The first commutator – type direct current electric motor capable of a practical application was invented by the British scientist William Sturgeon in 1832, following Sturgeon's work, a commutator – type direct – current motor made with the intention of commercial use was built by the American Thomas Davenpot and patented in 1837. Although several of these motors were built and used to operate equipment such as printing press, due to the high cost of primary battery power, the motors were commercially unsuccessful and Davepot went bankrupt. Several inventors followed Sturgeon in the development of DC motors but all encountered the same cost issues with primary batter power. No electricity distribution had been developed at the time. Like Sturgeon's motor, there was no practical commercial market for these motors. [4, 9].

The modern DC motor was invented by accident in 1873, when Zenobe Gramme connected the dynamo he had invented to a second similar unit, driving it as a motor. The Gramme machine was the first electric motor that was successful in the industry. [4, 10].

In 1888 Nikola Telsa invented the first practicable AC motor and with it the poly phase power transmission system. Telsa continued his work on the AC motor in the years to follow at the Westinghouse Company. [5]

1.1 AIM AND OBJECTIVES

This project work "single – phase reluctance start induction motors" is aimed at used in some home appliances and lower – power business appliance and in some places where three – phase appliance is not available.

This research work is often the first choice because of their durable construction, maintenance, free operation and low cost. [3].

1.2 AREA OF APPLICATION

These motors are used in, fans, blowers centrifugal pumps, centrifugal separators, washing machines, grinding machines, domestic refrigerators, and oil burners on the whole analysis, they are cheaper than the capacitor start type of motors.

1.3 METHODOLOGY

In order to understand how the single phase reluctance start induction motor works, a basic understanding of the physical principles and fundaments governing motor design and operation is required. We will start with the basic principle on which the induction motor is able to convert electrical energy into mechanical energy.

The basic operation of a single phase reluctance start induction motor is based on two electromagnetic principles:

1. Current flow in a conductor will create a magnetic field surrounding the conductor and
2. If a conductor is moved through this magnetic field, current is induced in the conductor and it will create its own magnetic field

The fundamental single phase reluctance start induction motor consists of two basic parts. These two parts are:

- Stator
- Rotor as Depicted below

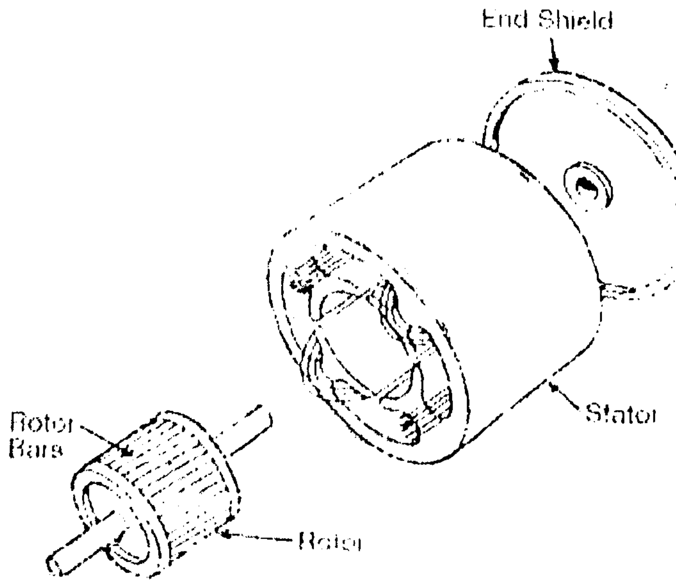


Fig 1.1 Basic Components of a single – phase reluctance start Induction motor

1. ***Stator:*** The stator is constructed of a set of stacked laminated discs which are surrounded by a stator winding. This winding is connected to the proper power supply (voltage, phase and frequency) and produces a magnetic field that revolves around the motor at a speed designated "synchronous".

2. ***Rotor:*** The rotor is connected to the output shaft and consists of a shorted aluminum winding which is cast in slots and stacked and joined at both ends of the stack with end rings. The rotor acts as a conductor which when placed in the magnetic field of the stator winding creates a magnetic field of its own and interacts with the magnetic field of the stator, producing torque.

CHAPTER TWO

2.0 LITERATURE REVIEW

Fractional motors are classified as single phase motors. The word "fractional" is used to indicate that the ratings are some fractions of a horse power of a motor rating.

Uses

They are used in refrigerators, grinding machine, fans, drilling machines, machines mostly used for domestic application, aviation industries, computers and communication equipments.

These machines are named after their constructional features and method of starting. They can be found as:

a. Induction Motors, which can be sub divided into

   i. Split phase

   ii. Capacitor

   iii. Shaded pole motors

b. Repulsion motors: These are also called inductive series motors

c. Alternating current series motor

d. Synchronous motors (unexcited)

2.1 UNEXCITED SINGLE PHASE SYNCHRONOUS MOTORS

These motors are found in two constructions:

1. Reluctance motor
2. Hystersis motor

Their characteristics are as follows:

a. They operate from a single phase A.C. supply

b. They run at a constant speed i.e. the synchronous speed of the rotating flux

c. They don't need D.C. excitation for their rotors that is why they are called unexcited motors.

d. They are self starting

The reluctance motors constructions are divided into two types viz:

a. The split phase type reluctance motor

b. The capacitor type reluctance motor

The split phase type has a stator of the convection split phase motor provided with a centrifugal switch to disconnect the auxiliary (starting) winding during running. The capacitor type, consist of a stator, identical to that of a permanent split capacitor run single phase motor.

The stator in either construction produces the rotating magnetic field. The rotor in either construction is similar. The main feature is that its construction produces asymmetric magnetic flux, which reacts with the rotating field to produce a starting and running torque. The asymmetric construction can be achieved by removing some of the teeth of a symmetric squirrel cage rotor as shown in Fig. 2.1. The construction provides a salient pole rotor, where the magnetic reluctance is not uniform in the air gap between the rotor and stator. This overall effect is that the reluctance offered by the rotor against the stator flux varies at different positions of the rotor. [1].

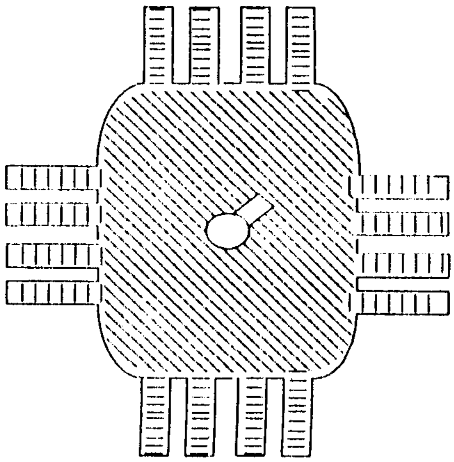


Fig. 2.1 Four pole rotor of a reluctance motor

A single phase reluctance motor is constructed so that either the rotor or the stator (or both) has poles in which there are areas of different. saturation induction (thereby forming an asymmetric saturation characteristic in these poles), as a result of which an aligned position of the movable member becomes non - aligned at increasing excitation current and the movable member begins to move in a predetermined direction.

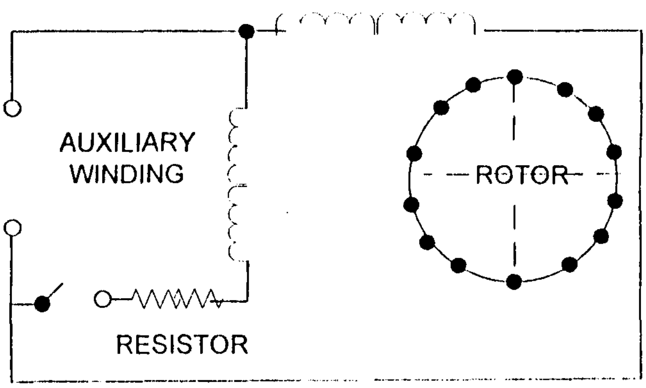


Fig 2.2 The Split phase type reluctance motor

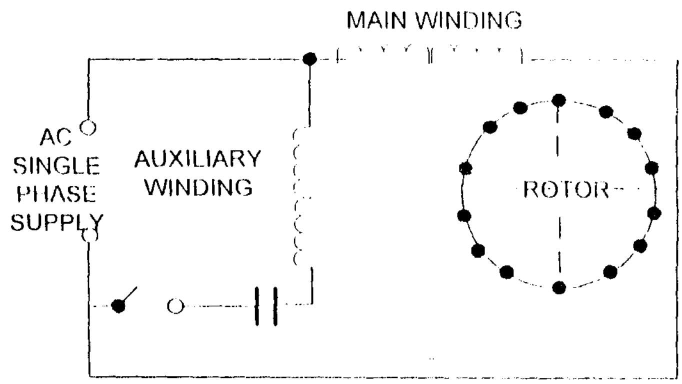
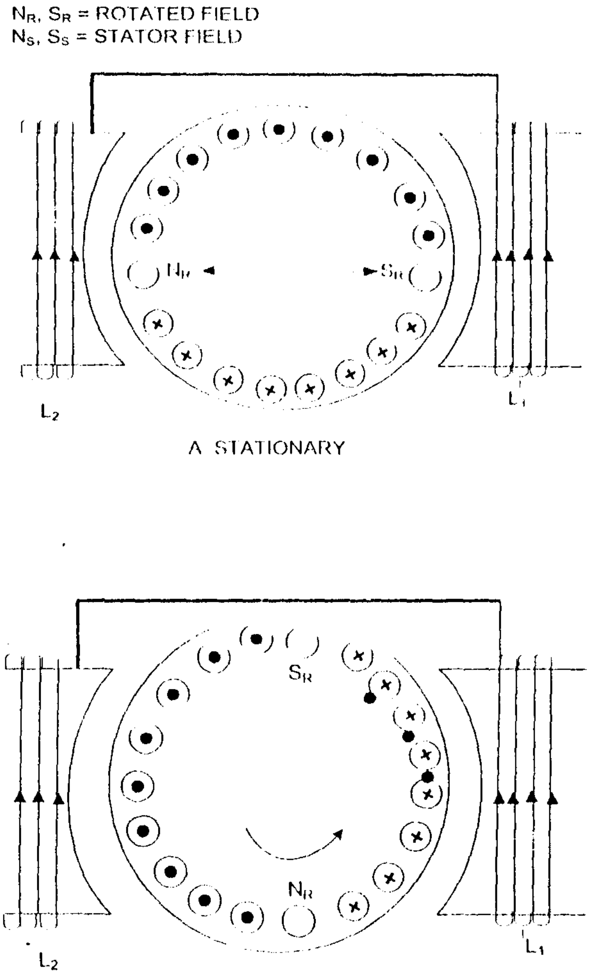


Figure 2.3 The capacitor type reluctance motor

A single phase reluctance motor comprising a stationary member and a movable member which is movable relative to said stationary member, an air gap being formed between said members, one member comprising a magnetically permeable ferromagnetic body having salient pole parts and the other member comprising an electrically excitable ferromagnetic body having salient pole parts, wherein one of the permeable ferromagnetic members is constructed in such a manner that comprises, spaced along the air gap circumference, first areas having a lower saturation induction and the second areas having a higher saturation induction to produce an asymmetrical saturation characteristic, as a result of which an aligned position of the movable member becomes non - aligned at increasing excitation current and the movable member begins to move towards a new aligned position as shown below [2]



A STATIONARY

B. ROTATING

Figure 2.4 Rotor Current in a single – phase reluctance start induction motor

2.2 DESCRIPTION

Reluctance motors basically comprise a stationary member (stator) and a movable member (rotor), the stator being provided with a single – phase or poly phase electrical winding which produces a magnetic flux through the stator and the rotor when a current is passed through the winding. The rotor and the stator consist of ferromagnetic materials which are readily magnetizable up to a certain maximum indication, the saturation induction; initially the induction in the material increases rapidly in response to an increasing current in the electrical winding and subsequently it increases only slightly. This effect is called saturation. The construction of a single phase motor is very simple.

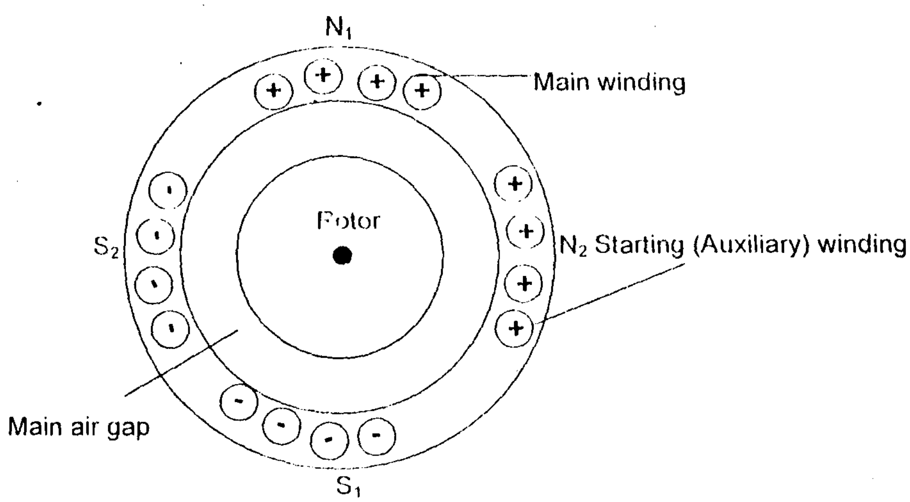


Fig. 2.5 Constructional feature of a typical single phase motor

Where N_1S_1 – North + south poles of main winding

N_2S_2 – North + South poles of auxiliary winding

The magnetic forces produced under the influence of the current cause the rotor to be rotated towards a position in which the rotor and the stator teeth are situated as closely as possible opposite one another, this is the so – called aligned position in which the stored magnetic energy is maximal. However, the initial direction of rotation of this single – phase motor is dependent on the initial position of the rotor and if the motor is already in the aligned position, it will not be rotated at all. The motor will then fail to start.

In order to avoid this, such motors are provided either with an auxiliary winding or with a holding magnet, which ensure that the rotor always remains in a or can be moved to (auxiliary winding) a given offset position relative to the aligned position [2]

CHAPTER THREE

3.0 DESIGN SPECIFICATIONS

Power P_2 = 100W

Voltage = 240V

Efficiency (η) = 35%

Power Factor (Cosφ) = 0.3

Speed (n) = 1500rpm

Number of poles = 2P = 4

Frequency F = 50Hz

Number of phase = M = 1

Speed, n = $\frac{120f}{2p} = \frac{120 \times 50}{4} = 1500rpm$

Rated milli – horse power (mhp)

$$mhp = 1000 \times \frac{watt}{746} = 1000 \times \frac{70}{746} = 93.8mhp \quad \text{...3.1}$$

3.1 CALCULATION OF THE MAIN DIMENSIONS THE D^2L

The volume of the rotor is approximately equal to $\frac{\pi D^2 L}{4}$ [6]

D = Stator internal diameter

This could also represent the rotor diameter since the air gap is normally very small.

The volt – ampere (VA) rating of the motor can also be expressed as:

$$S = \frac{P_2}{\eta \cos\varphi} = \frac{100}{0.35 \times 0.3} = \frac{100}{0.105} = 952.3VA \quad \text{......................................3.2}$$

Where P_2: output power = 100W

η: Efficiency = 35%

Cosφ: Power factor = 0.3

The output coefficient can be expressed as C_A = 11KWBg.A

Where KW: Winding factor = 0.92

Bg: Specific magnetic loading = 0.3T

A: Specific electric loading

C_A = 11 x 0.92 x 0.3 x 1600 = 48576

We have to introduce the pole pitch T_P [6]

$$T_p = \frac{\pi D}{2P} = \frac{3.142 \times D}{2 \times 2} = 0.7855D \qquad \text{3.1}$$

For the particular motor, the ratio of the stator length of the pole pitch is

K = 0.34

$$K = \frac{2PL}{\pi D} \qquad \text{3.2}$$

The length of the stator can be expressed as

$$L = \frac{K\pi D}{2P}$$

L = K x 0.7855D

= 0.34 x 0.7855D = 0.26707D

Since

$$D^2L = \frac{S}{C''_A} = \frac{952}{48576 \times 25} = \frac{952}{1214400} = 0.0007839m^3 \qquad \text{3.3}$$

Therefore

$D^2 \times 0.26707D = 0.0007839$

$D^3 0.267070 = 0.0007839$

Therefore

$$D = \sqrt{\frac{0.0007839}{0.26707}} = 0.1048m$$

The stack length of the stator of the motor is

$L_1 = 0.26707 \times 0.1048 = 0.02798m$

The outer diameter of the stator, $D_a = \frac{D}{K_D} = \frac{0.1048}{0.64} = 0.16375m$

K_D is a constant = 0.64

3.2 CORE LOSSES

These dimensions give a pole that does not depart seriously from a square. The pole pitch can now be deduced.

$$T_p = \frac{\pi D}{2P} = \frac{3.142 \times 0.1048}{2 \times 2} = 0.08232$$

3.3.1 Air Gap Length

$l_g = 0.2 + \sqrt[2]{DL}$ is the empirical formula 3.6.2 [6]

$= 0.2 + \sqrt[2]{0.1048 \times 0.02789}$

$= 0.2 + \sqrt[2]{0.002922}$ s

$= 0.2 + 0.10811$

$l_g = 0.30811mm$

But effective air gap = 0.5m

The no load flux φm is determined by $\varphi m = BgTL_1$

$\Phi m = 0.3 \times 0.08232 \times 0.02789$

$= 0.000689wb$

$\Phi m = 0.689mwb$

The number of turns per phase is determined by:

$$N = \frac{V}{4.44FKW\varphi m}$$

$$= \frac{240}{4.44 \times 50 \times 0.92 \times 0.000689}$$

$$= \frac{240}{0.14072}$$

$= 1705.51$

$= 1706turns$

The number of turns per pole is

$$N_T = \frac{N_1}{P} = \frac{1706}{4} = 427 \ldots\ldots 3.4$$

The number of stator slots per pole is chosen to be 4 i.e. g = 4

3.3.2 Specific Magnetic Loading Bg

The total flux of poles is PΦ webers and the total surface area of the air gap is π DL.

Therefore, $Bg = \frac{P\varphi}{\pi DL} wb/m^2 \ldots\ldots 3.5$

The value of Bg, the specific magnetic loading should not be so high as to cause magnetic saturation of teeth. The value of Bg for this design is chosen as 0.3T.

(Where T = 10b/m^2)

3.3.3 Pole Arc

b' = α g$_1$

Where α g= $\frac{2}{\pi}$ = 0.64 (pole arc coefficient)

Therefore b' = 0.64 x 0.08232 = 0.5268

3.3.4 Pole width

Bmp = 0.6b'

= 0.6 x 0.05268

= 0.0316m

The normal current is

$$I_1 = \frac{S}{MV} = \frac{952}{1 \times 240} = 3.966A$$

For average and 10W power 50Hz motors, current density ranges from 3 – 8A/mm^2.

Taking a current density of η – 4A/mm^2

The cross sectional area of the conductor is

$$A_1 = \frac{I_1}{\eta_1} = \frac{3.966}{4} = 0.992mm^2$$

3.3.5 Diameter of the Conductor

$$d = \sqrt{\frac{4A_1}{\pi}} = \sqrt{\frac{4 \times 0.992}{3.142}} = \sqrt{\frac{3.968}{3.142}} = \sqrt{1.2628}$$

d = 1.123mm

3.3.6 Rotor Computation

Rotor slots, since rotor bars have to be employed here, the number of rotor slots has been chosen as 22. The slot pitch of the rotor can be expressed as:

$$V_{S2} = \frac{\pi D}{S2} = \frac{3.142 \times 0.1048}{22} = 0.01496m$$

3.3.7 Equivalent Rotor Current

The equivalent rotor current I_2 is approximately expressed as:

$I_2' = I_1 \cos\varphi = 3.966 \times 0.3$

$I_2' = 1.1898A$

The number of rotor slots per pole is expressed as

$$g_2 = \frac{s2}{2P} = \frac{22}{4} = 5.5 \text{ Rotor slots/pole} \qquad 3.6$$

BAR CURRENT

The bar current I_b is expressed as $I_b = I_2' (2KWN_T/S_2)$

$I_b = 1.1868 (2 \times 0.92 \times 427/22) = 42.491$

Where

I_2' = The rotor equivalent current

KW= Winding factor

N_T = The number of turns per phase of the stator

S_2 = The number of stator slots

Taking $\eta_2 = 4A/mm^2$ as the current density should give a reasonable starting torque.

Area of bar is expressed as:

$$A_b = \frac{I_b}{\eta_2} = \frac{42.491}{4} mm^2 \text{.......................................} 3.7$$

$= 10.622mm^2$

The depth and width of the rotor bars can be deduced with due consideration to the area A_b.

Diameter of bar is given as

$$d_b = \sqrt{\frac{4A_b}{\pi}} \text{...} \; 3.8$$

$$= \sqrt{\frac{4 \times 10.622}{3.142}} = \sqrt{13.5225}$$

$= 3.68mm$

The slots are skewed on slot pitch. The length per bar L_b is 0.15m.

SHAFT DIAMETER

$$d_{shaft} = Ks\sqrt[3]{\frac{P_n}{n}} \text{..} 3.8$$

Where P_n = output power 70 x 10^{-3}

K_s = specific constant 32

n = synchronous speed 1500

Therefore

$$d_{shaft} = 32/\sqrt[3]{\frac{70 \times 10^{3}}{1500}} = 1.1520mm$$

3.3.8 Magnetic System computation Flux Density in the main pole

The flux density in the main pole can be expressed as Bmp =

$$\frac{\varphi_m}{S_{mp}} \text{...} 3.9$$

Where S_{mp}: Cross sectional area of the main pole

i.e. $S_{mp} = K_s L_1 bmp$

and $K_s = 0.93$

$L_1 = 0.02798$

$b_{mp} = 0.0316m$

Therefore $S_{mp} = 0.93 \times 0.02798 \times 0.0316 = 8.222 \times 10^{-4}$

Φm is the flux = 0.000689wb

Therefore $b_{mp} = \frac{0.000689}{8.222 \times 10^{-4}} = 0.83T$

3.4 The Main Flux Density in the Stator Core

The maximum flux density in the stator core can then be expressed as:

$$B_{a1} = \frac{\phi m}{2h_{a1} L_1 K_s}$$

Where φm = magnetic flux

L_1 = length of core

K_s = staking factor ($Ks = 0.93$)

$h_{a1} = \frac{D_2 \quad D}{2} \quad hp_1 = 0.02614$

Where h_{p1} = the depth of the stator slot

Therefore

$$B_{a1} = \frac{0.000689}{2 \times 0.02614 \times 0.02798 \times 0.93} = \frac{0.000689}{0.0013603}$$

$= 0.51T$

3.4.1 Flux Density in the Rotor Teeth

The minimum tooth width at the section of the rotor bt 2min can be expressed as:

$b_t2min = t_2 - bp_2$.. 3.10

$= 0.016 - 0.006$

$= 0.01m = 10mm$

The maximum tooth width bt2max of the rotor can be expressed as

$$bt2max = t_2 \ 1 + \frac{2hp_2}{D} \quad bp_2$$

$$= 0.016\left(1 + \frac{2 \times 0.01}{0.1048}\right) - 0.006$$

$$= 0.016\left(1 + \frac{0.02}{0.1048}\right) - 0.006$$

$b_t2max = 1.1848m$.

The average width of the rotor teeth bt2av is similarly expressed as:

$$B_t2av = \frac{bt2\max + bt2\min}{2} \text{.......................................} 3.11$$

$$= \frac{1.1848 + 0.01}{2} = 0.5974m$$

$$B_t2av = \frac{Bgt_2L_1}{bt2\min L_1K_s} = \frac{0.3 \times 0.016 \times 0.02798}{0.01 \times 0.02798 \times 0.93} = \frac{0.0001343}{0.0002602}$$

$= 0.52T$.. 3.11

The minimum tooth density of the rotor can be expressed as

$$B_t2min = \frac{Bgt_2L_1}{bt2\max L_1K_s} = \frac{0.3\times0.016\times0.02798}{1.1848\times0.02798\times0.93} = \frac{0.0001343}{0.03283}$$

$$= 0.0041T \qquad 3.12$$

$$B_t2av = \frac{B_t2\max + B_t2\min}{2} \qquad 3.13$$

$$= \frac{0.52+0.0041}{2} = \frac{0.5241}{2} = 0.26T$$

The height of rotor core h_{a2} is expressed as

$$h2 = \frac{D_a \quad D_{shaft}}{2} = \frac{0.1048 \quad 0.01152}{2} = 0.4664m$$

The symbols used above represent the following

D_2 = the external diameter of the rotor

D_{shaft} = the diameter of the shaft

b_{p1} = the width of the stator slot

K_s = stacking factor or block fill factor (for varnished sheet K_s = 0.93)

Y_{S1} = the slot pitch for the stator

Y_{S2} = the slot pitch for the rotor

The external diameter D_2 of the rotor can be deduced using the expression.

$D_2 = D - I_g = 0.1048 - 0.0005 = 0.1043$

The internal diameter of the rotor is given as 0.0923 – 0.01 = 0.0823 where 0.01 is the height of the rotor.

3.4.2 Length of Rotor

The length of rotor core is often taken a few millimeters longer than L_1 due to the end ring.

$L2 = L1 + 2(Ir)$... 3.14

Where Ir is chosen to be 0.003m

$L_2 = 0.02798 + 2\ (0.003) = 0.02798 + 0.006$

$= 0.03398m$

From the B – H curve we have that for sheeted steel

STATOR

Bmp = 0.83T Hmp = 688A/m

Bal = 1.76T Ha1 = 10, 000A/M

ROTOR

Bt2max = 0.8T Ht2max = 250A/m

Bt2min = 0.6T Ht2min = 156A/m

Bt2av = 0.676T Ht2av = 188A/m

$Ha_2 = 63A/m$

$H_{t2} = 1/6\ [H_{t2max} + 4\ (H_t2av) + H_t2min]$

$= 1/6\ [250 + 4 \times 188 + 156] = 193A/m$

The height of motor teeth is taken as $ht_2 = 0.01m$

3.4.3 M.M.F of the Air Gap

The MMF of the air gap is over 60% the total number of MMF in the motor (design)

The MMF of the air gap fg can be expressed as follows

$$Fg = \frac{B_g I_g K_g}{U_o} \quad \text{.........} 3.15$$

Where u_o: Permeability of free space

Kg: can be expressed as

$$Kg_1 = \frac{t_1}{t_1 \quad r_1 I_g}$$

And similarly

$$Kg_2 = \frac{t_1}{t_2 \quad r_2 I_g}$$

Where r_1 and r_2 are functions respectively of

$$\frac{bsp(I_g)^2}{s + \frac{bsp}{I_g}^2} \; and \; \frac{(bsp / I_g)^2}{s + \frac{bsp}{I_g}^2}$$

Obtained from the graph of carter coefficient for air gaps

$$\text{Since } r_1 = \frac{(610.0005)^2}{(5 + 610.0005)^2} = \frac{1.44 \times 10^8}{5 + 1.44 \times 10^8} = 0.999$$

Where $b_{sp} = 6$

$I_g = 0.0005m$

$t_1 = 0.020$ and $t_2 = 0.016$

From the above kg_1 becomes

$$Kg_1 = \frac{0.020}{0.020 \quad 0.999 \times 0.0005} = 1.0256$$

$$Kg_2 = \frac{t_2}{t_2 \quad rI_g} = \frac{0.016}{0.016 \quad 0.999 \times 0.0005}$$

$= 1.0323$

$Kg = kg_1 \times kg_2$

$= 1.0256 \times 1.0323$

$= 1.0587$

$= 1.0587$

The MMF of the air gap Fg becomes

$$Fg = \frac{0.3 \times 0.0005 \times 1.0587}{4\pi \times 10^{-7}} = \frac{1.588 \times 10^{-4}}{12.566 \times 10^{-7}}$$

$= 1.2637 \times 10^{-1} \times 10^{3}$

$= 1.2637 \times 10^{2}$

$= 126.37 = 126.4$amp

$$Hg = \frac{B_g}{U_o} = \frac{0.3}{4\pi \times 10^{-7}} = 2.38739 \times 10^{-2+7}$$

$= 2.38739 \times 10^{5}$

$= 238739$amp – turns

3.4.4 M.M.F in the Rotor Teeth

The used equation is expressed as $Ft_2 = ht_2 Ht_2$

Where ht_2 is the height of the rotor slot

Therefore

$Ft_2 = 0.01 \times 193 = 1.93A$

MMF in the rotor core Fa_2

Length of path can be expressed as

$$La_2 = \frac{\pi(D_2 + D_{shaft})}{2P}$$

$$= \frac{(0.01048 + 0.01152)\pi}{4} = 0.09135m$$

$Fa_2 = Ha_2 \times La_2 = 63 \times 0.09135 = 5.75505A$

MMF of main pole

$F_{mp} = H_{mp} \times L_{mp} = 0.01 \times 688 = 6.88A$

MMF in stator core

Length

$$La_1 = \frac{1}{C_s} \times \frac{\pi}{P} \times \frac{(D_1 + D_s)}{2}$$

$$= \frac{1}{45} \times \frac{\pi}{4} \times \frac{(145 + 102.8)}{2} = 0.0216$$

$Ha_1 = 10,000$

$Fa_1 = 10,000 \times 0.0216 = 216A$

3.7.6 Total M.M.F of the Magnetic Circuit of the Machine

$F_{total} = F_g + F_{mp} + Fa_1 + Fa_2 + Ft_2$

$F_T = 126.4 + 6.88 + 216 + 5.75505 + 1.93$

$= 356.96AT$

K_i = Saturation factor of the magnetic circuit can be expressed as:

$$K_i = \frac{F_T}{F_g} = \frac{356.96}{126.4} = 2.824$$

The magnetizing current Im can be expressed as

$$I_m = \frac{1.11Fr}{N \times Kw \times Cos\varphi}$$

$$= \frac{1.11 \times 356.96}{1325 \times 0.92 \times 0.866} = \frac{396.2256}{1055.654}$$

$= 0.3753A$

Taking $0 = 30^0 = 0.866$

Therefore No – load current is approximately

Therefore No – load current is approximately

$I_o = 0.3753A$

i.e. $I_o = \sqrt{(Iom) + (Ioa)^2}$

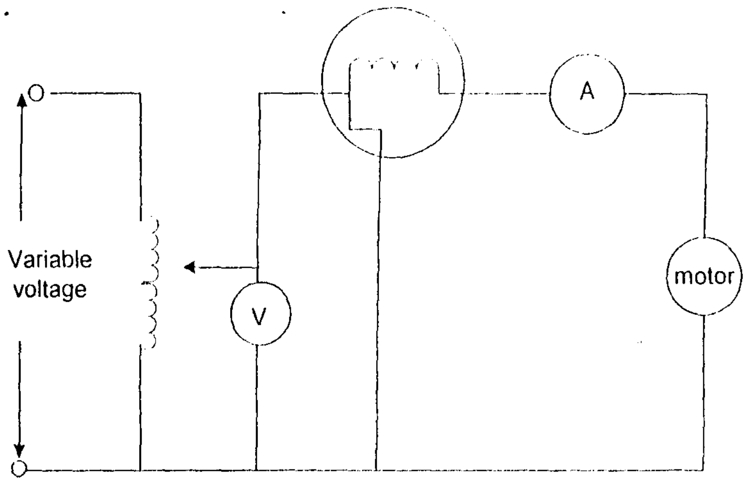


Figure 3.1 The stand still parameters of the motor

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

For the purpose of this project work which is basically a design work, only the result and discussion will be areas of focus.

The speed of the rotating rotor was calculated from the rated values to be 1500rpm. The rated millihorse power (mhp) is 93.8mhp.

The volume of the rotor is approximately equal to 0.0006157, which is gotten from the cylinder formula i.e. $\frac{\pi D^2 L}{4}$, where D is the stator internal diameter and L is the length of the stator.

Output power = 100W, the volt – ampere (VA) rating of the motors = 952.3VA. While, efficiency = 35% and power factor = 0.3. The pole pitch, Tp = 0.7855D.

Length of the stator = 0.267071D

The magnetic loading, B_g = 0.3T, the value chosen for B_g will cause a magnetic saturation of the teeth.

The number of turns per pole is gotten to be 427 for a 4 stator slots per pole [7].

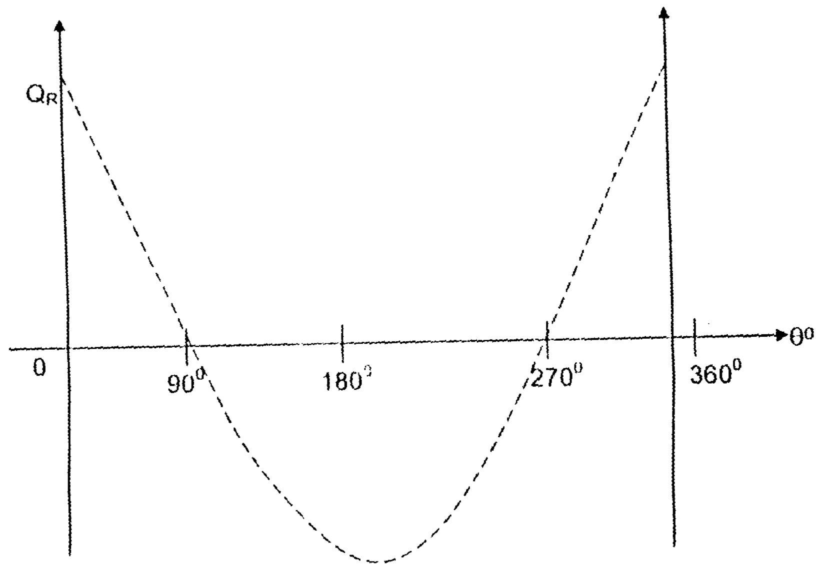


Fig. 4.1 Resultant flux ϕ_R versus θ graph of the Alternating current

From fig. 4.1 above, No load flux φm = 0.689mwb thus, the resultant flux φ_R is given as - φm, therefore φ_R = - 0.689mwb.

At θ (where θ is the angle of rotation of the rotor)

If they rotate further from the reference point "O" is now 90^0, then the resultant flux $\varphi_R = 0$, this is because $Sin\theta = Sin90^0 = 1$ and the magnitudes of the two fluxes are cancelled out.

Further rotation to an angle of 180^0 from reference point O, the value of the $\varphi_R = \varphi m$.

At 270^0 $\varphi_R = 0$

The value of the current density $\eta = 4A/mm^2$ which will give reasonable starting torque. Also the magnetic current, I_m = 0.3753A and no – load current I_o = 0.3753A.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The design of a single – phase reluctance motor which, without the use of an auxiliary winding or holding magnet is capable of producing in any position a torque which enables the motor to be started from any initial position and which also enables a desired initial direction of rotation to be defined is what this whole design work is made to achieve. [8].

According to the design this object is achieved in that one of the permeable ferromagnetic members is constructed in such a manner that it comprises, spaced along the air – gap circumference, first areas having a higher saturation inductance, as a result of which an aligned position of the movable member becomes non – aligned at increasing excitation current under the influence of the different saturation characteristics and the movable members begins to rotate towards a new aligned position.

A thorough analysis of the operation of a reluctance motor has shown that the mechanical position of the rotor and stator teeth is not the decision factor for the generation of the torque in a specific direction but that the motor will rotate in this direction if the magnetic energy stored in the motor increases in this direction. In principle, this is

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